Current Technology Options to Reduce Climate Forcing in the Global Power Generation Sector: Overview, Alternatives, Issues

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Abstract

This paper examines the broad potential of various new and retrofit electric generating technologies to reduce two major climate forcing emissions from the power sector: nitrogen oxides (leading to tropospheric ozone formation) and CO2. We also examined the impact of these technologies on sulfur dioxide emissions. Using a spreadsheet approach, we applied a series of technology scenarios to projected 2025 and 2050 electric demand in the United States, India and China. These countries make up about 40% of world power demand today and as projected for 2030 and broadly represent current and projected patterns of power system growth and technology in the OECD and developing world. The scenarios include (1) Business as Usual (current emission rates expanded to forecasted 2025 and 2050 demand); (2) application of best available control technology (BACT) for nitrogen oxides and sulfur dioxide to all BAU fossil energy production; (3) production of ***all*** global electricity from integrated combined cycle coal gasification (IGCC) coupled with carbon capture and geologic sequestration (CCS); and (4) production of 50% of global electricity from IGCC/CCS and 50% from generic "zero emission" resources (which could include nuclear, wind, PV etc.). We also analyzed scenarios that held in place all currently installed 2002 plants during the study period, allowing technological change only in incremental electric production.

While these scenarios are deliberately simplified, they do suggest some broad themes:

- *Retrofit technology can be a powerful tool in reducing non-CO2 climate forcing agents or health-damaging pollutants such as NOx and SO2.* Universal application of BACT technology to existing fossil energy plants and all new fossil energy plants by 2025 and 2050 reduces global power sector NOx and SO2 emissions to less than 2002 levels, even allowing for nearly quadrupled demand from 2002-2050, and to an even smaller fraction of 2025 and 2050 BAU emissions. Such technology is routinely installed at new coal plants in the OECD, and it

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is beginning to be installed at new coal plants in developing countries. It would be technically and economically feasible to install NOX and SO2 emissions controls on most existing coal plants that lack such controls; this retrofitting is already well underway in the US and increasingly in China. Thus, an initiative to reduce power generation NOX and SO2 emissions to very low levels over a multi-decade period is plausible and would probably be cost-justified by reduced health and environmental impacts. Prodding power sector NOX emissions down sooner to reduce background ozone concentrations and associated climate forcing is a manageable task over a 10 - 20 year period.

- *Gasification and zero emissions resources provide small additional gains in reducing non-CO2 pollutants.* Universal application of half IGCC/CCS and half zero emissions technology provides smaller further reductions in NOx and SO2 emissions compared to BACT, although these reductions may be thought large enough in some cases to add to the climate-based justification for these resources.

- *Gasification and geological sequestration powerfully reduces CO2; additional CO2 control gains from zero emissions resources are small.* Universal application of IGCC/CCS technology to quadrupled demand in 2050 all supplied by coal would reduce power sector CO2 to a fraction of its 2002 levels and a much smaller fraction of BAU. Changing the power mix to include half zero emissions resources such as wind and nuclear provides only modest additional CO2 reductions, although they may be thought large enough to justify the incremental costs. In addition, early addition of these resources can delay build-up of CO2 in the atmosphere until carbon sequestration becomes cost-justified.

- *The fate of existing plants matters much more in the US than in China and India, where post-2002 stock dominates 2050 emissions.* Because electric demand in the United States is expected to grow only modestly in the next 50 years, most of the emissions improvements relative to BAU or 2002 emissions must necessarily come through replacing or retrofitting existing plants. By contrast, in China and India, only 12% of possible year 2050 generation volume is currently in operation today, making the emissions from the new fleet of paramount importance. In later years, this distinction may collapse as most of today's US units are likely to retire by 2050.

Apart from this scenario analysis, other evidence suggests:

- *While costs of various new generating and retrofit options vary, they are likely to change their relative relationship over 50 years and come down in real terms.*

Accordingly, financial pain from adopting low emissions technologies, while substantial, is likely to be bigger in the next two decades than afterwards. (There may, however, be exceptions where technologies stall out in cost reductions due to fuel price increases, inherent heat rate limits, and other factors.) Near-term policies aimed at reducing the cleaner technologies' higher costs are thus of great importance.

- *Timing matters.* Because of the long residence time of CO2 and the long life of power generating assets, it is disproportionately important to avoid siting of new conventional coal plants not readily amendable to carbon sequestration, and to retire existing high-polluting plants as soon as possible.

- *The size of the climate management challenge suggests that no currently available low-carbon resource should be a priori taken off the table.* It is unlikely that any one or two electric resources – IGCC/CCS, nuclear, or wind – can be scaled up in sufficient volume by 2050 to alone reduce baseline power sector carbon emissions by 50% or more.

- *Because of the size of the climate challenge, spurring innovation to create new low-carbon generating technologies is of great importance.* This is especially crucial for the rapidly-industrializing world, where electric demand is growing at rapid rates, and decisions are being made today that will have long-lived effects.